THE TELEGRAPHIC JOURNAL.

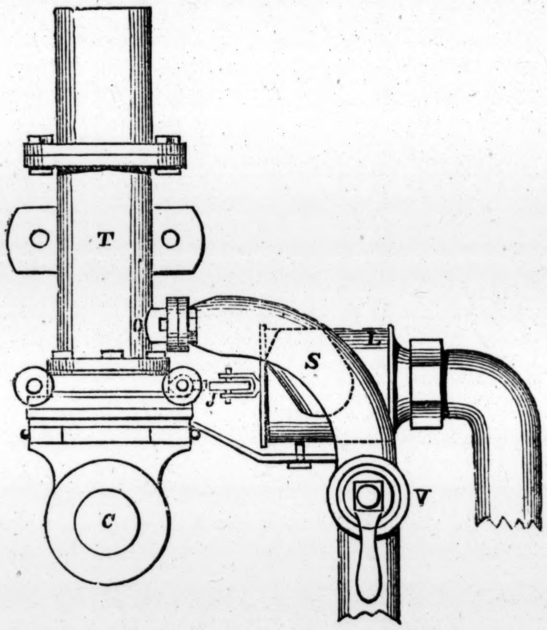
Vol. II.—No. 26.

# REPORT OF M. DELARGE ON THE SYSTEM OF PNEUMATIC TUBES EMPLOYED IN ENGLAND.

(Continued from vol. i., page 295).

The system of Mr. Clark as modified by Mr. Varley is applied in 16 directions, one of which is not in service. Seven of these tubes are furnished with valves designed by Mr. Varley; the rest have the more simply constructed valves of Mr. Willmot. This difference excepted, the arrangement is the same in both cases; the tubes and cases are the same, and the same machines serve for all the directions. A single tube is placed between the central office and the office in relation with it (at least if the traffic is not such as to require a second apparatus). Cases containing telegrams are sent from the central office to the other by means of compressed air, and are sent from the latter to the former by means of a vacuum produced in the former. The valves for transmission and reception are only found at the central office.

Fig. 1.



The tubes are of lead; they are 0·038 m. diameter in certain of the directions, and 0·0571 m. in others. Their thickness is 0·005 m. in the former case, and 0·006 m. in the latter. Their length is 5·50 m. Two tubes are joined end to end by a soldering which has to be made with the greatest care, so as to avoid the least roughness in the interior. For this purpose, a steel cylinder previously heated, and having exactly the diameter of the tube, is introduced into the ends of the two that are to be joined; the soldering then applied at the joint. This done, the cylinder is removed by means of a chain attached to it.

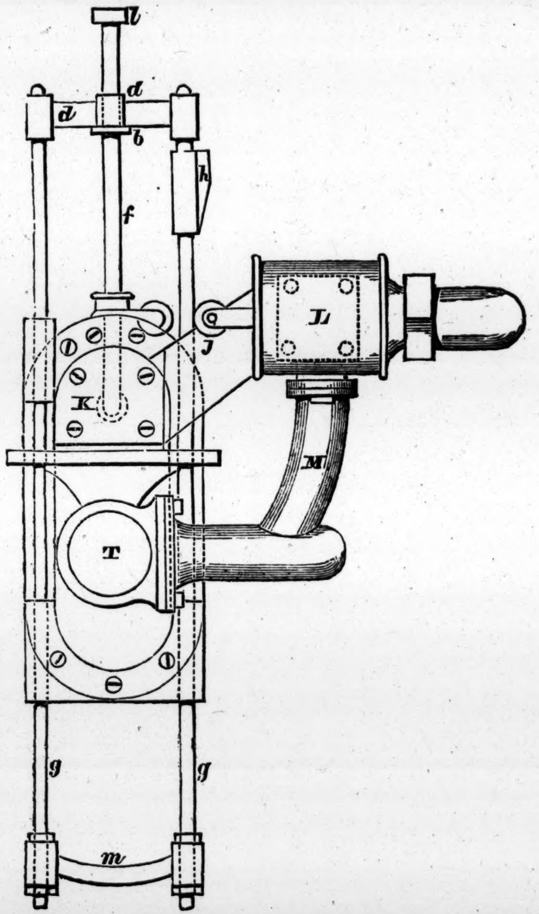
Before joining the tubes, they are brought to the required diameter by passing through them a steel cylinder, with round anterior edge, and connected by a chain with a winch. Before this operation the tubes have a slightly less diameter than the cylinder. When they have been calibrated, they are transferred to wooden cases open above.

These tubes are buried in the ground at a depth of 0·60 m., and they are then protected by cast-iron pipes.

The smallest radius generally given to the curves of the tubes is 2·44 m. In the curves, the iron pipes are made of two pieces, the upper being fixed on the lower (after insertion of the lead pipes) by bolts passing through the collars. There is no reservoir for water in the tube; the little moisture produced by the compressed air is absorbed by the felt coating of the cases.

The cases are of gutta-percha; they are 0·004 m. thickness, and 0·145 m. total length; the exterior diameter of the cylinder is 0·037 m. for tubes of 0·057 m. The anterior part is made thicker to resist shock. An elastic band 0·015 m. breadth, envelopes the case in the direction of its length, and partly covers its open end, so as to prevent the escape of the telegrams during transport. An envelope of ordinary felt, covering the whole, prevents any heating and melting of the gutta-percha from direct friction. This envelope has the form of a funnel, that the felt may be compressed against the walls of the tube by the air pressure. A series of felt washers at the anterior end of the case also help to form a piston, and protect the gutta-percha from the effects of shocks. These cases last a long time.

Fig. 2.



After two months' service, the felt and elastic envelopes are generally renewed (the cost being 0·20fr. for the felt, 0·20fr. for the elastic, and 0·20 fr. for work).

[M. Delarge describes Mr. Varley's valves, which are somewhat complicated and costly]. Figs. 1 and 2 show the most recent arrangement of Mr. Willmot's valves. T is the continuation of subterranean tube.

To receive a case, one stops the lower end of this tube by raising the hinge valve C (which has caoutchouc packing); then one turns the stopcock V, thus putting the tube in communication with the vacuum chamber. A vacuum is produced, and the valve is kept closed by atmospheric pressure. The case on arrival forces it open, but losing its *vis viva* on the shock, it is held by atmospheric pressure against the mouth O of the tube S. As soon as the attendant sees the valve C fall, he closes the cock V, and the case being no longer held by external pressure, falls out of the tube T.

The mode of sending a case is as follows: one puts it in the tube T (Fig. 2), then, by means of the handlebar *m*, pulls the sliding apparatus formed by the rods *g* and the crossbar *d*; which latter meets the ring *b* fixed on the rod *f*, and carries this on with it. The obturator K, fixed to the end of *f*, is thus brought to close the extremity of the tube T. When this closure is complete, the inclined plane *h*, fixed on one of the rods *g*, meets and pushes back the roller *j*, thus opening a valve within the cylinder L, and establishing communication between the reservoir of compressed air, and the tubes M and T. The case is then forced forward in the tube, and whenever its arrival is announced by the electric bell, the slider is pushed back to its normal position.

If the rod *f* were connected fixedly with the crossbar *d*, a certain effort would be required to push back the slider, owing to the friction due to pressure on the surface of the obturator. This effect is avoided by making the rod *f* slide in the crossbar between the limits *b* and *l*. For, in pushing back, the inclined plane first leaves the roller *j*, and the compressed air ceases to enter the tube, then the crossbar meets the ring *l*, and the rod *f* removes the obturator easily. These valves cost 375 fr. and 625 fr. Most of the pieces composing the valves are of brass. They are fixed to strong blocks; one vertical, the other horizontal; the latter forming a tablette for the cases.

In all the other offices, the arrangement is as follows:—

The subterranean tube terminates in a wooden box, of cube shape, 0·35 m. width. The anterior face has a door, with pane of glass in it, turning on two hinges in the upper horizontal edge, and opening from without inwards. This case rests on another much larger one, lined with lead; and communicating by a pipe from its lower part with the drains. An iron grating in the partition between the cases allows air to pass from one to the other.

When a dispatch case is to be sent, it is placed in the end of the tube, and the central office is then signalled to make a vacuum.

When a case is being received, the air it drives before it closes the door, and escapes through the grating, without inconvenience to the attendant.

The communication with the drains is, besides, necessary for getting rid of the water used in flooding the tubes, in order to expel cases that may have been accidentally stopped. When this process becomes necessary, the tube is filled with water, and the air is compressed to the greatest degree possible. As the pneumatic tubes terminate on the third floor, the pressure of the column of water is added to that of the compressed air. This method is always effectual.

At its entrance into the building the tube is connected by a pipe from the point of lowest level, with a box having two stopcocks; one of these lets the water escape, the other establishes communication with the vacuum chamber. The pipe connected with the dispatch tube has also a stopcock; this, and the one for outflow are opened, and when all the water is escaped the latter is closed, and the other cock (vacuum) opened; any moisture which remains is then removed through suction.

In the electric bells used in signalling, only one hammer knock is given each time the current is sent. Each time a signal is received, a disc falls before an opening in the box of the bell, and remains in this position till raised by the hand.

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# MATHEMATICS
FOR
# NATURAL SCIENCE STUDENTS.

By T. C. SIMMONS, B.A. Magdalene College, Cambridge.

(Continued from page 99.)

### QUADRATIC EQUATIONS.

An equation which contains the square of $x$, and no higher power, is, as I said before, called a *quadratic equation*, or more briefly, a *quadratic*. It is easily seen that there is an essential difference between it and a simple equation. If we have to solve one of the latter, we always can reduce it to the form $a \, . \, x = b$ where $a$ and $b$ are known quantities, and so obtain $x = \frac{b}{a}$, but we cannot do this in a quadratic, as we have two separate terms, one containing $x^2$, and the other $x$. How then are we to proceed? I shall indicate the way directly. Before doing so, I would make a few observations about a fact which makes quadratics very different from simple equations. It is this:—Every quadratic equation has *two* roots,* while, as we have seen, in a simple equation we only get one value for $x$. To take a simple case—

$$x^2 = 9.$$

This is a quadratic equation; and at first sight it may appear that it only has one root, 3. For the student may argue thus: If we square any number greater than 3, the result must be greater than 9, and if we square any number less than 3, the result must be less than 9; so that no number except 3 can, when squared, become 9. He has forgotten, however, that there are to be conceived such things as negative numbers; and though their existence is, as it were, only perceived by an effort of the imagination, still it is necessary to take account of them, and to treat them just the same as if they were numbers with which we have to deal in practical life, such as 3, or 4. Now, if we multiply $-3$ by $-3$, we get 9, so that $x = -3$ is a solution, and $-3$ a root. $x = 3$ is, of course, the other solution, and 3 the other root. But why does $-3$ become 9 if squared? Why do two minuses in multiplication produce a plus? This is a question which I cannot answer directly, nor do I recollect seeing it explained by any writer in a form which would be understood by non-mathematicians. I may, however, argue in an indirect way, thus:—

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* A *root* of an equation is a value of the unknown quantity which satisfies the equation.

$5-3$ is equivalent to 2, so that $5-3$ multiplied by 3 produces the same result as $2\times3$, *i.e.*, 6. But $5\times3=15$; thus, to get 6, we must subtract 9, and we thus see that—

$$5-3 \text{ multiplied by } 3 \text{ becomes } 15-9.$$

So $4-3$ becomes $12-9$, $6-3$ becomes $18-9$, and so on. Therefore we may conclude that, since $-3$ may be written $0-3$, if we multiply it by 3 it becomes $0-9$ ($3\times0$ being 0)—

or $$-9$$

Thus $$-3\times3=-9.$$

In a similar way I might show how it may be seen that—

$$3\times-3=-9$$

and also—

$$-3\times-3=+9.$$

Thus, the equation $x^2=9$ has two roots, $+3$ and $-3$. So $x^2=16$ has two roots, $+4$ and $-4$, $x^2=25$ two roots, $+5$ and $-5$, and so on. If $x^2$ be equal to a number which has no exact root, we may still say the same thing, so that if $x^2=7$, for instance, there are two roots, $+\sqrt{7}$ and $-\sqrt{7}$, where $\sqrt{7}$ stands for $2.64\ldots.$ or the quantity which is the arithmetical value of $\sqrt{7}$. But suppose $x^2$ is equal to a negative quantity, as $-3$, how should we then proceed? We know that a positive number multiplied by itself produces a positive number, and that a negative number does so likewise. How then can any number when squared become negative? The answer is this:—We cannot find any number, positive or negative, to satisfy an equation such as $x^2=-3$, so that we may say that it has no roots. It is more convenient to say, however, that it has two impossible roots, $+\sqrt{-3}$ and $-\sqrt{-3}$. The reader may regard such expressions as $\sqrt{-3}$ and $-\sqrt{-3}$ as symbols if he pleases, and not as quantities; indeed a theory has been given in Professor De Morgan's "Trigonometry" which treats them as symbols. In whatever light, however, we regard them, it is usual to say that an equation such as $x^2=-9$ has two solutions, viz., $x=+\sqrt{-9}$ and $x=-\sqrt{-9}$, or $x=\sqrt{9}\times\sqrt{-1}$, or $3\sqrt{-1}$, and $x=-3\sqrt{-1}$.

I have thus considered every form of the equation $x^2=a$, where $a$ is any arithmetical number, positive or negative. I proceed to equation of the form—

$$x^2+2ax=b,$$

and before indicating the method of solving them, I would ask the student whether he is familiar with algebraical multiplication. If not, it is necessary that he should know something about it.

Now, if we multiply $x+a$ by $x+a$, we should proceed thus:—Put the multiplier under the multiplicand, as in arithmetical multiplication, and multiply each term of the multiplicand by each term of the multiplier, and add up for the result. Thus—

$$\begin{array}{lll} x & +a & \\ x & +a & \\ \hline x^2 & +ax & \\ & ax & +a^2 \\ \hline \end{array}$$

$$\text{Result } x^2+2ax+a^2$$

Thus $x^2+2ax+a^2$ is the square of $x+a$.

Now, in the equation—

$$x^2+2ax=b$$

add $a^2$ to both sides. Thus—

$$x^2+2ax+a^2=b+a^2$$

or

$$(x+a)^2=b+a^2.$$

Take the square root of each member, thus (since if two quantities are equal, so also are their square roots)—

$$x+a=+\sqrt{b+a^2}.$$

We also have—

$$x+a=-\sqrt{b+a^2},$$

since, if we multiply $-\sqrt{b+a^2}$ by $-\sqrt{b+a^2}$, we get $b+a^2$. Thus we have two values for $x+a$, viz., $+\sqrt{b+a^2}$ and $-\sqrt{b+a^2}$; we may express them both at once thus, $\pm\sqrt{b+a^2}$, where the symbol $\pm$ denotes either the $+$ sign or the $-$, which we please.

Thus—

$$x=-a+\sqrt{b+a^2}$$

or

$$=-a-\sqrt{b+a^2}$$

which are the two solutions.

Suppose, now, we have the equation—

$$x^2+6x=16$$

or

$$x^2+2.3x=16.$$

Here, corresponding to the $a$ in the previous example, we have 3. Add, then, $3^2$ to both sides, we then get—

$$x^2+2.3x+3^2=16+9$$

or

$$(x+3)^2=25$$
$$x+3=\pm5$$
$$x=-3\pm5$$

If we take the upper sign, or $+$, in the ambiguous $\pm$, we get $-3+5$, or 2. If we take the lower sign, or $-$, we get $-3-5$, or $-8$. Thus there are the two roots, 2 and $-8$.

Let us test them by substituting either of them for $x$ in the original equation. If we take 2, we get—

$$2^2+6.2=16$$

or

$$4+12=16,$$

which is obviously true. Take $-8$, and we get—

$$(-8)^2+6(-8)=16$$

or

$$64-48=16,$$

which is true. Thus we know that the roots 2 and $-8$ which we found are correct.

Take another example—

$$x^2+2x=8$$

Add $1^2$ to both sides—

$$x^2+2x+1=8+1$$
$$(x+1)^2=9$$
$$x+1=\pm3$$
$$x=-1\pm3$$
$$=-4, \text{ or } +2$$

Thus $-4$ and $+2$ are the roots. They will be found on substitution to satisfy the equation, so that we know them to be the accurate solutions.

Again—

$$2x^2+8x=24$$

Divide by 2, thus—

$$x^2+4x=12$$

Add $2^2$ to both sides, then—

$$x^2+4x+2^2=12+4$$

or

$$(x+2)^2=16$$
$$x+2=\pm 4$$
$$x=-2\pm 4$$
$$=+2, \text{ or } -6.$$

Either of these values will satisfy $2x^2+8x=24$ if substituted for $x$; thus we know them to be correct.

I will now give rules for solving quadratic equations:—

(1). Reduce the equation so that $x^2$ occurs without a coefficient on the left hand side, and the term involving $x$ next it on the same side, and known quantities on the other side.

(2). Add to each side the square of half the coefficient of $x$; extract the square root of each side, and the equation is solved. We must always remember, however, that the double sign $\pm$ must be used when we extract the root.

*Examples:—*

(1). $$x^2+15=8x.$$

Proceeding according to rule (1)—

$$x^2-8x=-15,$$

Add to each side the square of half of $-8$, or the square of $-4$, which is 16, thus—

$$x^2-8x+4^2=-15+16$$
$$(x-4)^2=+1$$
$$x-4=\pm 1$$
$$x=4\pm 1$$

and the roots are $+5$ and $+3$.

(2). $$x^2+4x=7$$

Add $2^2$ to each side. Then—

$$x^2+4x+2^2=7+4$$
$$(x+2)^2=11$$
$$x+2=\pm\sqrt{11}$$
$$x=-2\pm\sqrt{11}$$

and the roots are $-2+\sqrt{11}$ and $-2-\sqrt{11}$.

(3). $$4x^2+20x=11$$

or

$$x^2+5x=\tfrac{11}{4}.$$

Add $(\frac{5}{2})^2$ to both sides. Then—

$$x^2+5x+(\tfrac{5}{2})^2=\tfrac{11}{4}+\tfrac{25}{4}$$
$$(x+\tfrac{5}{2})^2=\tfrac{36}{4}=9$$
$$x+\tfrac{5}{2}=\pm 3$$
$$x=-\tfrac{5}{2}\pm 3,$$

and the roots are $-5\frac{1}{2}$, $+\frac{1}{2}$.

(4). $$x^2+6x=-10$$
$$x^2+6x+3^2=-10+9$$
$$(x+3)^2=-1$$
$$x+3=\pm\sqrt{-1}$$
$$x=-3\pm\sqrt{-1}$$

Thus both roots are impossible, and they are $-3+\sqrt{-1}$ and $-3-\sqrt{-1}$, and in this case there is no number, positive or negative, which will satisfy the equation.

(5). $$x^2+cx=0$$
$$x^2+cx+\left(\frac{c}{2}\right)^2=\frac{c^2}{4}$$
$$\left(x+\frac{c}{2}\right)^2=\pm\frac{c}{2}$$
$$x=-\frac{c}{2}\pm\frac{c}{2}$$
$$=0, \text{ or } -c.$$

We might have solved this equation, however, thus:—

Divide by $x$. Then—

$$x+c=0$$

or

$$x=-c.$$

Where has the other root gone to? It almost seems as if we have only obtained one root by this method, whereas a quadratic equation must always have two roots. We must remember, however, that we cannot divide by any quantity involving $x$ without putting that quantity $=0$ for one solution. Thus, we divide by $x$, and in doing so, we must obtain one solution from the equation $x=0$.

Thus, 0 and $-c$ are the roots, the same as in the other way of solving it.

(6). $$(x-a)(x-b)=0.$$

This is a quadratic; for, if we multiply together the two factors $x-a$ and $x-b$, we shall get an equation involving $x^2$.

To solve it, divide by $x-a$ (remembering the solution $x-a=0$, or $x=a$, in doing so), and we get—

$$x-b=0.$$

Thus $x=b$, and $a$, $b$ are the roots.

I add some examples for the student to work out for himself:—

(7). $x^2-x=12$
Roots 4, $-3$.

(8). $x^2-25=0$
Roots $+5$, $-5$.

(9). $2x^2+6x=8$
Roots 1, $-4$.

(10). $x^2+12=7x$
Roots 3, 4.

(11). $x^2+8x=3$
Roots $-4+\sqrt{19}$, $-4-\sqrt{19}$.

We have now become acquainted sufficiently with algebra, and in my next paper I intend to proceed to the study of trigonometry. I shall endeavour to make it as interesting as possible, and hope I shall succeed in leading the student to a clear and accurate knowledge of the subject. If at any time he meets with a difficulty in any of these papers, he should think over it carefully; then if he cannot see it, he should lay it aside, and return to it after a few weeks. He will often, by this means, find that he is able to overcome it. If finally he is not able to satisfy himself, I shall be glad, either through the columns of this journal, or privately, to help him, if he will communicate the exact nature of his difficulty.

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**Physical Society.**—A numerously-attended meeting was held on the 14th ult. in the Physical Laboratory at the Science Schools, South Kensington, for the purpose of establishing a Physical Society in London. The chair was taken by Dr. J. H. Gladstone. The bye-laws prepared by the Organising Committee appointed on Nov. 29 were received and amended. The following were chosen officers for the first session:—*President*—Dr. J. H. Gladstone, F.R.S. *Vice-Presidents*—Prof. W. G. Adams, F.R.S., and Prof. G. C. Foster, F.R.S. *Secretaries*—Prof. E. Atkinson, and Prof. A. W. Reinold. *Treasurer*—Prof. E. Atkinson. *Demonstrator*—Prof. F. Guthrie. *Other Members of Council*—W. Crookes, F.R.S., Prof. A. Dupré, Prof. T. M. Geodeve, M.A., Prof. O. Henrici, B. Lœwy, Dr. E. Mills, and H. Sprengel.

# THE PRINCIPLES AND PRACTICE OF ELECTRICAL TESTING.

By SAMUEL E. PHILLIPS.

## II.—*The Laws of Propagation.*

POTENTIAL, tension, or electro-motive force is the static force, or difference of tension, by which all current is produced. With one cell it varies in proportion as the opposite elements differ electrically. This refers chiefly to the two metals, but the two constituents of the electrolytic fluid have a corresponding share in the function, and every case of battery action is really a chemical double decomposition, where two binary pairs exchange to a better or stronger equilibrium of their attractive forces.

If in chemistry we mix two binary salts, and have a double decomposition, with liberation of heat, as the product of the action, then we have the essentials of battery action, and all that is necessary is to convert this mass of local action—this confused assemblage of atomic interchanges—into a linear or circuit form, which is voltaism.

With many cells, the force varies as the number; two cells give double force, three cells treble force, and so on. Ohm's law expresses the force or quantity of current flowing in every possible case as—

$$\frac{E}{R} = Q,$$

E being the electromotive force, Q the quantity of current, and R the total resistance of the circuit; therefore ten cells, if R have the same value—

$$= \frac{10E}{R} = 10Q,$$

or a tenfold force in the circuit. In other words, we may say that this formula means that in every case the amount of current is *directly* as the force, and *inversely* as the resistance. With double the one we get two, with double the other we get half, and so on with all varied proportions; hence, with ten cells, if R comprises only their internal resistances, and no external work be done, we have—

$$\frac{10E}{10R} = Q,$$

the same as with one.

In regard to resistance, the first thing to observe is that two parallel wires of equal length convey equal quantities. It is so with tubes conveying water from a given pressure or potential, and must be so inherently. In either case, if we halve the size, the resistance will be doubled, and half the quantity conducted; whereas if the other be halved in length, the resistance will be halved, and its conductivity doubled. Hence it is seen that resistance and conductivity are inverse aspects of the same thing, and hence, also, the general statement that resistance varies *directly* as the length, and inversely as the square of the diameter.

Conduction takes place through the whole mass, therefore it varies directly as the weight, or as the square of the diameter. Given two wires, what are their conductivities? With a pocket gauge, we find that A is 0·0625 in., or about a No. 16°, while B is about No. 20, or with a diameter of 40 mils. 0·040 in. I then compare the squares of these figures, and find they are related as 1 to 2, and infer that A is double the weight, or has double the conductivity of B. The assumption here is that both have the same quality of metal, but as this varies considerably, its expression is provided for in the term, "specific conductivity." Calling the conductivity of pure copper 100, that now used for cables and other electrical purposes is often 96—98, and should never be less than 90; we now know, however, that some of the earlier cables had copper whose specific conductivity varied as low as 33. Starting from a mass or area of 1 square inch, it will be seen that we cannot double it both ways without having a fourfold area. For parallel or compound circuits, the equation is provided that "*the product of the two resistances, divided by their sum,*" equals their joint resistance, or—

$$\frac{A \times B}{A + B} = x.$$

We have seen that two tubes of equal size and length must convey double the quantity from a given hydro-motive force, and just so it is with wire circuits, where two resistances of 10 each have a double conductivity, or half the resistance—

$$\frac{10 \times 10}{10 + 10} = 5.$$

The same principle applies to three or more circuits, for which we must first take two, and then combine that joint resistance with a third, and so on. We can see beforehand that three such circuits would give a three-fold conductivity on one-third resistance; hence—

$$\frac{5 \times 10}{5 + 10} = 3{\cdot}33.$$

With several such circuits it is simpler to estimate their relative conductivities, and add them together for a total conductivity, whose inverse value is that of the total resistance.

The rule for this is thus expressed:—"*Add together their reciprocals, and the sum will be the reciprocal of their joint resistance.*" Now the reciprocal of any number is one divided by that number; hence, if we have 3 circuits, proceeding from a common source, of 30—60 and 80 units, the joint resistance will be 16 units.

| Resistances. | | Conductivities. |
|---|---|---|
| 30 | = | 0·0333 |
| 60 | = | 0·0166 |
| 80 | = | 0·0125 |
| | | Total 0·0625 |

whence—

$$\frac{1}{0{\cdot}0625} = 16.$$

or, simpler still in the case above, where 10 and 10 units = 5, we have—

$$0{\cdot}1 + 0{\cdot}1 = 0{\cdot}2 = \frac{1}{2} = 5.$$

In every case it will be seen that the current must divide itself in the ratio of the two resistances, and hence the simple equation for estimating the shunts of any galvanometer and their multiplying power, things of constant use in all forms of testing. The resistance of a shunted galvanometer is as above, viz., "the *product* by the *sum*," and the amount of current flowing through the galvanometer is in the ratio of the two resistances.

Suppose a galvanometer too sensitive to measure a given current, and that its resistance be 500 units, and its terminals short-circuited by a resistance of 100 units. In this case, the ratio is one to five, and the conductivities being inversely in this ratio, it follows that 5 parts of the current would flow in the shunt to one in the galvanometer; therefore, the equation for the multiplying power becomes—

$$\frac{G}{S}+1=x, \text{ or } \frac{500}{100}+1=6,$$

which means that a deflection of say 40° would be 40×6=240°, since, if we imagine the current divided into 6 parts, 5 would go through the shunt and only 1 through the galvanometer.

If we wish any galvanometer to have a given combined resistance, it is—

$$\frac{G \times R}{G-R}=S,$$

or the shunt required.

It is well that the student should grasp the full meaning of these formulæ, and understand them electrically; for this purpose it would be well to to lay them aside, and work out the results from the principles thus far reviewed.

We may conclude this paper by a few preliminary remarks on the galvanometer. We have seen that every current of electricity induces a static polarity at right angles to its direction, or transversely all round it, and that whether in the liquid or in the wire the same amount of inductive action subsists in every part of the circuit; hence this magnetic or directive tendency in a helix is multiplied by the number of turns.

For the measurement of large quantities of low tension, we have a few turns of thick wire, in many cases not more than one, while for more attenuated currents of higher tension, we have 5000 or more turns. The effect of this directivity in the case of a small piece of iron placed in the interior would be, first, to magnetise it, and secondly, to give it an axial direction.

In practice, we use a small magnetic needle, so arranged that the zero position, under the influence of terrestrial magnetism, is to point in the line of the coil, or transversely to its axis.

The true function of a galvanometer is to measure the quantity of electricity circulating, irrespective of its intensity. To do this truly involves complex considerations, which we shall refer to when we are treating of the construction and uses of varied appliances in future details.

The true functions of an electrometer is to measure tension or potential, irrespective of the quantities affected.

Despite these essential distinctions, we may often have to estimate tension by a galvanometer, but then it is not a direct process. The fact is, the two things are closely related, and often symmetrically or numerically dependent. With a given deflection, or the same quantity flowing in two cases, if we can ascertain collaterally that one has a circuit of double resistances, then it follows that the tension or electromotive force must in that case be double; and conversely we can in a similar *indirect* way estimate quantity by an electrometer which measures only potential.

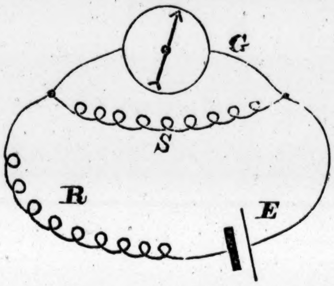
THE AMERICAN AUTOMATIC TELEGRAPH.—The American Automatic Telegraph System is now being operated in the United States by the Automatic Telegraph Company under an agreement, with a temporary license granted by George Little, who informs us that he is ready to assign one-fourth part of all the foreign patents now in his possession.

## Students' Column.

*Resistances and their Measurement.*—By H. R. Kempe.

VII.—In making certain measurements we sometimes find that, owing to the sensitiveness of the galvanometer used, we are unable to obtain a readable deflection, from the needle being deflected up to the stops. We may reduce this sensitiveness by the insertion of a *shunt* between the terminals of the instrument. This method is shown in Fig. 10.

FIG. 10.



If it is required to reduce the strength of current which ordinarily passes through the galvanometer to any proportional part of that current, we must calculate, from the resistance of the galvanometer, what the resistance of the shunt should be to reduce the current to that proportional part. Now if we call C the current passing through the galvanometer without a shunt, on introducing the shunt we shall split C between the two resistances in the inverse proportion of those resistances; that is to say, the greater portion of the current will go through the smaller resistance, and the smaller portion through the greater. Thus if we divide the total current, which passes from one terminal of the galvanometer to the other, into G+S parts, $\frac{G}{G+S}$ parts will go through the shunt, and $\frac{S}{G+S}$ parts through the galvanometer; that is to say, the current going through shunt is—

$$C\frac{G}{G+S},$$

and current going through galvanometer—

$$C\frac{S}{G+S}.$$

If, in this last quantity, we put S=G, then current going through galvanometer will be—

$$C\frac{G}{G+G}, \text{ which equals } \frac{C}{2}.$$

Again, if we make $S=\frac{G}{2}$, current going through galvanometer will be—

$$C\frac{\frac{G}{2}}{G+\frac{G}{2}}, \text{ which equals } \frac{C}{3}.$$

And again, if S be made equal to $\frac{G}{3}$, current going through galvanometer will be—

$$C\frac{\frac{G}{3}}{G+\frac{G}{3}}, \text{ which equals } \frac{C}{4}.$$

Finally, if S be made equal to $\frac{G}{n-1}$, current going through galvanometer will be—

$$C\frac{\frac{G}{n-1}}{G+\frac{G}{n-1}}, \text{ which equals } \frac{C}{n}.$$

From this it is evident that, to reduce the current flowing through the galvanometer to its $\frac{1}{n}$th part, we must insert a shunt whose resistance is $\frac{1}{n-1}$th part of the resistance of the galvanometer.

In many galvanometers three shunts are provided, which enable us to reduce the strength of current flowing through it to its $\frac{1}{10}$th, $\frac{1}{100}$th, or $\frac{1}{1000}$th part. From what has been said it will be evident that the resistances of the shunts necessary to produce these results will have to be respectively the $\frac{1}{9}$th, $\frac{1}{99}$th, and $\frac{1}{999}$th part of the resistance of the galvanometer.

We are thus enabled to reduce the sensitiveness of a galvanometer to any proportion we wish. Suppose now, in making an experiment, we placed a resistance-box for a shunt between the terminals of the galvanometer, and then adjusted it until we got a convenient deflection for the purpose we required; what deflection should we get on removing the shunt? Let us call C, as before, the current which passes through the galvanometer when no shunt is inserted, and let $C_1$ be the current which flows through it when the shunt is inserted, then the current which flows through the shunt will be—

$$C - C_1.$$

Now the two currents will flow through the shunt and galvanometer in the inverse proportion of their resistances, that is—

$$C_1 : C - C_1 :: S : G$$

therefore—

$$C = C_1 \times \frac{G+S}{S}$$

Or expressed in words, we should say that the current which would flow through the galvanometer, when the shunt is removed, will be $\frac{\textit{Galvanometer + Shunt}}{\textit{Shunt}}$ times the strength of the current which flows when the shunt is inserted. This proportion is often called the *multiplying power* of a shunt.

It will be noticed that when a shunt is introduced between the terminals of a galvanometer which is in a circuit like that shown in Fig. 10, on introducing a shunt which reduces its sensitiveness to ½, that is to say a shunt having a resistance equal to that of the galvanometer, we shall not halve the current passing through the galvanometer. If we used a tangent galvanometer, we should find, if the deflection without the shunt was 40 divisions on the tangent scale, the introduction of the shunt would not bring the deflection down to 20, but to some deflection greater than 20. The reason of this is, that the introduction of the shunt reduces the total resistance in the battery circuit, and consequently increases the strength of the current passing out of the battery. It is this increased current, then, which splits between the galvanometer and shunt, and not the original current. To make up for this decreased resistance caused by the introduction of the shunt, it is necessary to add in the battery circuit a compensating resistance equal in value to the amount by which the original resistance was reduced. This is thus obtained.

The resistance between the terminals of the galvanometer before the introduction of the shunt being G, the introduction of the shunt reduces the resistance to $\frac{GS}{G+S}$. The resistance, therefore, to be added in the battery circuit will be—

$$G - \frac{GS}{G+S} = \frac{G^2}{G+S}$$

Now as S is usually made some fractional value of the galvanometer resistance, say the $\frac{1}{n-1}$th part (which value would be used in reducing the sensitiveness of the galvanometer to $\frac{1}{n}$th), we may write the value of the compensating resistance as—

$$\frac{G^2}{G+\frac{G}{n-1}}, \text{ which equals } G\,\frac{n-1}{n}.$$

Example: With a galvanometer (G), whose resistance is 100 ohms, it is required to reduce its sensitiveness to $\frac{1}{5}$th. What should be the resistance of the shunt and of the compensating resistance?

Resistance of shunt equals—

$$100 \times \frac{1}{5-1} = 25,$$

and compensating resistance equals—

$$100 \times \frac{5-1}{5} = 80.$$

A galvanometer of a resistance G, with a shunt inserted and compensating resistance added, may be regarded as a galvanometer whose resistance is also G, but whose sensitiveness is diminished. It would be as well if all galvanometers provided with shunts were also provided with compensating resistances, as calculation would be considerably simplified thereby in a large number of measurements.

It is evident that if, in making a measurement, we want to reduce the deflection of our galvanometer to a readable deflection, we can do so, either by placing a large resistance in the battery circuit, or by introducing a shunt between the terminals of the galvanometer. It is possible, of course, also to produce the same effect by placing a shunt between the poles of the battery, but this method causes a needless waste of battery material, and also interferes with its constancy. It may be stated as a general rule, but especially when measuring *small* resistances, that it is better to reduce the sensitiveness of a galvanometer by the use of a shunt, rather than by introducing resistances in the battery circuit.

(To be continued.)

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## PAPERS FOR JUNIOR STUDENTS.

*Formulæ Analysed.* By ARTHUR R. GRANVILLE.

III. *On Shunts and Shunt Circuits.*—Whenever a current of electricity of great strength, or high electromotive force, is passed through a sensitive galvanometer a violent deflection of the needle is produced. It is extremely desirable to avoid a violent swing of the needle when testing, not only on account of inconvenience, and waste of time experienced in waiting for the needle to recover its equilibrium, but because large readings on an ordinary galvanometer are unreliable, and also more especially because of the great risk of demagnetising the needle by energetic charges.

For this reason it is usual, in most tests, to divert a portion of the current from entering the galvanometer, such that the strength indicated will be an $n$th part of the battery power. An apparatus to split the current in the requisite proportion is called a shunt. Shunts are resistances of a lower range than that of the galvanometer, and are so made that say only a $\frac{1}{10}$th, $\frac{1}{100}$th, $\frac{1}{1000}$th, or any other selected fraction of the battery current can go through the galvanometer, whilst the remaining portion passes direct through the shunt on to the line wire. The "tangent," or the "sine," of the angle of the deflection of the needle is proportional to the strength of the current; hence we know that if $\frac{1}{n}$th of the current gives $a°$ deflection, the whole battery power would have given $na°$ deflection. The constant $n$ constitutes therefore the multiplying power of the shunt.

Every galvanometer requires its own shunts, which, as a rule, are now sold with them; but should it happen that these instruments are not at hand when required, a formula to calculate the required resistance is all that is necessary for the telegraphist to contrive an apparatus to suit his purpose.

Any conductor of less resistance than the galvanometer, such as a rheostat, or definite lengths of wire, may be used—anything, in fact, that will prevent the whole of a large current entering the galvanometer by conducting the main part of it direct to the line. The formula to determine the shunt resistance is $\frac{G}{n-1}$, where $n$ is the multiplying power of the shunt, and G the resistance of the galvanometer: the ratio of the galvanometer and shunt resistances becomes $G : \frac{G}{n-1}$. The truth of this symbol may be deduced from the following simple considerations, in which it is as well to state no account is taken of other resistances in the circuit than those of the galvanometer and the shunt:—

1. When a shunt of any value, $x$, is added to the galvanometer, the total resistance is $G+x$.
2. The ratio of the resistance of the shunt to the total resistance is represented by $\frac{x}{G+x}$, and in like manner that of the galvanometer is $\frac{G}{G+x}$.
3. The path of the current is inversely as the resistances. The portion therefore entering the galvanometer will be according to the value of $\frac{x}{G+x}$.
4. The strength of the current assumed to traverse the galvanometer is $\frac{1}{n}$th of the whole; hence $\frac{x}{G+x}=\frac{1}{n}$.

From these propositions is obtained the equation—

$$(G+x)\cdot\frac{x}{G+x}=\frac{G+x}{n}$$

$$x=\frac{G+x}{n},$$

and by continuing the operation, to eliminate the unknown quantity $x$ from the right-hand member, it becomes—

$$nx-x=G$$

$$x(n-1)=G$$

$$x=\frac{G}{n-1},$$

which is the formula previously quoted, and means that the resistance of a shunt must equal that of the galvanometer divided by the proposed multiplying power diminished by unity. For instance, it is desired to reduce to $\frac{1}{10}$th the sensibility of a galvanometer of 2700 ohms; then—

$$\frac{G}{n-1}=\frac{2700}{10-1}=300 \text{ ohms},$$

the required resistance of the shunt.

The *value, n,* has been before mentioned to represent the number by which the deflection of the needle is to be multiplied in order to calculate the strength of the whole current. It indeed renders the reading *with* the shunt equal to the reading *without* it, and its algebraic symbol is $\frac{G+s}{s}$ or $\frac{G}{s}+1$. The process by which this general term is obtained may be briefly stated thus:—

$e$ = electromotive force of the battery ......$\alpha$
$e'$ = current traversing the shunt ............$\beta$
$e-e'$ = " " galvanometer ......$\delta$.

$\beta$ and $\delta$ are in the inverse ratio of the resistances of the two circuits; therefore the proportionals are—

$$G : s :: e-e' : e'$$

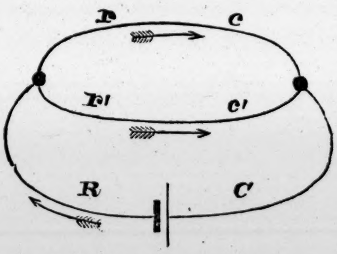
$$\frac{e-e'}{e'}=\frac{G}{s}$$

$$\frac{e}{e'}-1=\frac{G}{s}$$

$$e=e'\left(\frac{G}{s}+1\right)$$

from which it is at once perceived that the strength of the battery, if allowed to pass in its entirety through the galvanometer, would give a deflection equal to that of the diminished current *multiplied* by $\left(\frac{G}{s}+1\right)$, the value of $n$.

Fig. 1.



In *shunt circuits* arranged as below the following formulæ relative to the joint resistances of conductors, and the divisions of currents in a circuit, are often met with.

The joint resistances of R, $r$, and $r_1$ are—

$$R+\frac{r\,r_1}{r+r_1}.$$

The current, C, will therefore equal—

$$\frac{E}{R+\frac{r\,r_1}{r+r_1}}=E\frac{r+r_1}{Rr+Rr_1+r\,r_1} \quad . \quad . \quad . \quad (1)$$

and in accordance with the explanation of the split of the current in Article II.—

$$C_1=\frac{r_1}{r+r_1}\left(\frac{E\,(r+r_1)}{Rr+Rr_1+r\,r_1}\right).$$

$$=E\frac{r_1}{Rr+Rr_1+r\,r_1} \quad . \quad . \quad . \quad . \quad (2)$$

and similarly—

$$C_2=E\frac{r}{Rr+Rr_1+r\,r_1} \quad . \quad . \quad . \quad . \quad (3)$$

Equations (1), (2), (3), (4) are quoted by Mr. Clark in his "Electrical Tables," pp. 30 and 31. He also mentions that A PARALLEL CIRCUIT, $x$, *of unknown resistance*, added to a line of known resistance, $a$, will give a total resistance of R ohms; then $x$ the resistance added $=\frac{Ra}{a-R}$. For $R=\frac{xa}{x+a}$, and—

$$xa=R(x+a)$$

$$x\,(a-R)=Ra$$

$$x=\frac{Ra}{a-R}.$$

(To be continued).

## Proceedings of Societies.

### SOCIETY OF TELEGRAPH ENGINEERS.

**The** ordinary meeting on the 11th ult. was presided over by Mr. C. W. Siemens, C.E., F.R.S., &c., Vice-President of the Society.

A paper, having for its subject "*Electric Torpedo Defences*," and of which the subjoined is an abstract, was read by Mr. **Nathaniel J. Holmes**:—The importance of a well constituted system of electric torpedo mines, as a means of defence against the approach of an enemy by sea or by land, is now recognised by most governments. When the system is properly constructed and laid down, and placed in the hands of skilful operators, rifled guns and armour plated vessels should be powerless for the attack against the destructive effects of the electric torpedo defence. In the report of the Secretary of the United States Navy, published as far back as December, 1865, when the torpedo system was only in its infancy, and manipulated by the Confederate engineers, under every possible disadvantage, it is stated that when the United States fleet attacked and passed the heavy forts erected for the sea defences of Mobile and of Wilmington, mounting together nearly six-hundred guns, many rifled and of the heaviest calibre, "the only vessels lost by the United States Government in both these attacks (and the shore batteries of the Confederates were splendidly served) were destroyed by electric torpedoes which, always formidable in harbours and internal waters, have proved more destructive to our naval vessels than all other means combined." Too much attention cannot, therefore, be directed to this comparatively new system of warfare, combining, as it does, economy in cost, efficiency in action, safety in working, security in defence, and devastation in effect. Recent experience demonstrates that perfection in the mechanical appliances for the attack or the defence is equivalent to the effective strength of numbers; and as mechanical appliances can be obtained at a less cost than the maintenance of a standing reserve, the defence of a kingdom resolves itself, in great part, into the establishment of properly applied scientific systems as against the two often lavish expenditure of revenue in the construction of unwieldy armaments competing for mastery in the never ending contest which the increased power and strength of each continually provokes. With the electric torpedo this competition ceases. The most powerful monitor or armour-plated ship ever constructed easily falls a prey to its deadly embrace. Half a dozen men in control of the torpedo mines can effectually keep at bay both an army and a fleet, and, at will, should either encroach within range of their "area of destruction," annihilate in a few seconds the advancing foe, or at least fatally cripple him. During the American civil war, the important defence of the water approach to Richmond was entrusted to a single electric torpedo mine sunk in the channel-way of the James River. This mine was under the control of an officer who, stationed on one of the river banks, watched from the sand pit where he lay concealed the approach of the enemy. For thirteen months did this officer remain waiting for the opportunity to explode the mine with effect. At length the Federal fleet, under command of Commodore Lee, entered the James River, the admiral's vessel being the third in the advancing rank. The mine was held in reserve for the destruction of the admiral's ship. An order, audible on the shore, having been passed from the deck of the next vessel, for her to fall back and drag for torpedo wires, the officer determined to explode his mine, and "hoist" her as she descended the stream. The explosion was witnessed by several persons. The hull of the vessel was visibly lifted out of the water; her boilers exploded, the smoke stacks were carried away, and the crew were projected into the air with great velocity. Out of 127 men, only three escaped alive. The vessel was literally blown into atoms, or using the American phrase, into "toothpicks." This paralysed the operations of the Federal fleet for a time, and Richmond was saved. Destructive as are the effects of torpedo explosions, there is little room to doubt that the introduction of science with naval and military tactics exercises a most wholesome effect on the moral physique of the men, accelerates the termination of a war, and is also a deterring element in the political exigencies which would hasten such a conflict. The torpedo, to be used as a defence in warfare, must be reduced to a definite system, defined in its principles and practical in its applications; and, like the practice of gunnery, become a recognised branch of military and naval instruction. It is likewise necessary that the electrical arrangements shall ensure the ignition of the torpedoes by land and sea, at distances exceeding that of the effective range of cannon, and that, when necessary, more than one mine shall be exploded in group, simultaneously on the same circuit. The following points may, therefore, be enumerated as the essential conditions of a torpedo system of defence:—(1.) The torpedoes in themselves must be non-explosive and harmless, not liable to accidental discharge by percussion or carelessness. (2.) The power of testing at all times the submarine or land circuits of the torpedoes without danger of explosion, and of speaking and of telegraphing information and instructions through the charge without risk. (3). The power of igniting the mines at will, and of discharging several torpedoes in group with a single wire at distances exceeding that of the effective range of artillery, and that the explosions shall only take place when the vessel or vessels to be destroyed are within the area of destruction. (4). The power of discharging the mines, even should the enemy succeed in breaking one of the conducting wires, and of preventing the explosion of the mine by the enemy. Every torpedo in its complete form consists of three parts—the ignitor, the charge, and the torpedo-case or tank, together with the necessary internal and external arrangements of electric connections, and conductors giving the operator the entire control of the mine. When the necessary precautions are observed, all danger of involuntary explosion is removed, and accidents become impossible even in the hands of inexperienced officers. The power of testing the effective condition of the circuits and connections within the torpedoes, and of speaking through the mines without danger of ignition, so as to maintain telegraphic communications between the several outlying stations and the centre of action, constitutes one of the important features of the Holmes and Maury system developed by them in 1863, during the civil war in America, and one which has more than any other contributed to inspire that confidence in the submarine and subterranean torpedo which the value of the invention demands. The importance of this result cannot be over estimated, when the value of telegraphic communication in active service is considered. The experience of the recent victories of the Prussian armies in Bohemia points to the great importance of maintaining telegraphic communication between the outposts, stations, and outlying divisions of the army, in regulating the successful issue of their military manœuvres. The same rule applies equally to naval tactics. For instance, let it be supposed that the enemy's fleet is advancing up channel; with this system orders could be immediately transmitted from station A to station B, directing attention to such and such a group of mines under certain instructions to be given during the progress of the attack, or the emergencies of the moment, and the transmission of such intelligence, while it places the whole field under the control of the commanding officers, at the same time points out the integrity of the several electric circuits. The recent Franco-Prussian war affords a very instructive example of the inefficiency of a divided attack or defence in the absence of special telegraphic communication. The well appointed and expensively maintained French naval force sent into the Baltic to carry out concerted operations by land and sea, to effect a diversion in favour of a land attack upon the enemy, was practically useless and inoperative from the absence of telegraphic communication from head quarters, directing the manœuvres and organising the diversion. Thus a most valuable opportunity for an effective land attack along the Prussian frontier, coincident with a naval engagement off the southern shore of the Baltic, of immense importance to France at that critical time, was absolutely and entirely lost, and all joint and reciprocal action between the French army and naval forces completely frustrated. The ignition of the electrical mine has next to be considered. Delay or doubt for a moment upon this point might prove fatal to the prospects of victory. A vessel steaming, say, at the rate of nine knots an hour, will move through the water at the rate of 18 feet per second; and supposing her length to be 300 feet, she will remain in position to receive the effects of the blow only 16 seconds. In every system of torpedo defence, the attention and consideration of the engineer should first be directed to ascertaining a knowledge of the ground, the currents, the depth of water, and the rise and fall of the tide over the area in which it is intended to carry out the system. Special arrangements must be carried out to secure the immovability of the mine in the position originally assigned to it, as torpedo mines may be months submerged before called into active use. The velocity of the current, and the depth or cushion of water form an important consideration in the effective manipulation of the mine. The depth at which torpedo mines are submerged is again of vast moment in relation to the strength of the charge. Water being, for all practical purposes, considered as incompressible in every direction, the effective action of the mine will always traverse the path of least resistance, or in other words in a vertical direction; but it does not always follow that this is practically the case, should the power of the charge and the inertia of the resistance be improperly calculated. It is on record that Admiral Chabanne, when trying some experiments with submerged electrical mines from the jetty at Toulon found that the effective force of the mine was conveyed along the bed of the ocean; and, the force of the explosion being thus transferred to the piles of the jetty, the operating party on the pier were knocked down, or rather " hoist by their own petard," while the surface of the ocean over the mine remained perfectly tranquil. In this instance the strength of the charge, in relation to the depth of water or resistance to be overcome, and to the conducting or vibrating power of the bed of the sea, had been miscalculated. The depth of water being too great for the charge, and the resistance of the ground between the mine and the jetty being less than the resistance of the water, the effective power of the mine, taking the path of least resistance, found vent in the vibratory motion it communicated to the ground. The important part which electricity is destined to play in future naval and military operations is scarcely recognised, or there would not be such an amount of money expended in vain attempts to introduce elaborate mechanical contrivances, which are in most instances totally unsuitable for active service in heavy seaways and tides. The too frequent misapplication of inventive genius is much to be lamented. During the American war, General Grant's operations against Richmond were frustrated through a mechanical mine failing to go off. Another most important lesson, as regards the employment of mechanical mines in warfare, is afforded by the Prussian defence of the mouth of the Elbe, in the recent Franco-Prussian war. The navigation of the river was closed by the use of mechanical torpedoes, but closed not only against the enemy, but also against the Prussian ships; and the lamentable loss of life to the Prussian engineers in the manipulation and placing of these mines is of too recent a date to be forgotten. Not only were the engineers exposed to great danger in the handling of these mechanical volcanoes, but at the termination of the war, when it became necessary to remove all such obstructions to navigation, there was a frequent reccurrence of fatal explosions. Not only may every mechanical system of torpedo defence, whether by land or by sea, be denounced as dangerous to the officers employed to manipulate it; but, from its necessarily uncertain action, it is liable to prove most disastrous in connection with any organised or concerted system of land or sea attack. Too much stress cannot be given to enunciate the importance of the employment of the electrical agent in all our naval and military armaments wherever practicable, in place of the mechanical toys which at present too often occupy the attention of naval and military departments throughout Europe. The practical applications of the electrical agency as a means of defence may certainly be dated from 1864, the period of the civil war in America. Disastrous as its application was to the United States fleet, the American Government have fully recognised the electrical agency as one of the most potent means of protecting their naval and military positions from the approach of any hostile force. In carrying into effect the laying down of any system of electric mines for a defence, it is of the first importance to observe secrecy in the details of position and the area over which the mines are placed. As there are various systems of arrangement and detail of manipulation in connection with the circuits and the mode of igniting the charge, it is not intended in this paper to advocate any special method. The nature of the channel, tideway, depth of water, sea bottom, and land approaches will, of necessity, to a certain extent, regulate and suggest to the torpedo engineer the means best calculated to ensure successful operations against the advance of an enemy. In speaking of electrical warfare in this paper, the author has regarded the system in the light of an established national defence. The paper then contained some brief practical suggestions in relation to certain features which should form part of a national scheme of torpedo defence, and this part of the subject was illustrated by means of diagrams. The precise manner of the discharge and ignition of the mines does not fall within the scope of this paper. It is sufficient to call attention to the fact that the use of chemical detonating fuses, wherever the mines may be of long duration, should be avoided. Time, temperature, and electric action greatly affect the integrity of the chemical detonator. Wherever the ignition of the mine can be effected by the heat evolved by the resistance of fine platinum wire, that mode is greatly to be preferred, as certain in its action, however long the mine may have remained in position. It is on record that the whole of the chemical fuses sent out for the defence of Richmond, but which, through the fall of Wilmington and Mobile, failed to reach their destination, were returned to this country after lying a year at Havannah, and were found to be utterly useless for their purpose, not one fuse in a hundred fulfilling the essential condition of instantaneous ignition. The exhaustive experiments made at Bowdon, near Manchester, in 1863, by the late Lieut. M. F. Maury and the writer of this paper, with reference to the effect of the continued action of weak currents of electricity upon the sensitiveness of the chemical fuse, were conclusive against any reliance being placed upon that form of ignitor for any permanent system of electric defence. We can store our gunpowder, without detriment, from year to year. So also must our electrical defences be safe from deterioration, even though years intervene between the placing and the discharge of the mines.

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Professor Abel said that he was sure that they had all listened with very great interest to the lucid manner in which Mr. Holmes had laid before them the conditions which should be fulfilled by an efficient system of torpedo defence. On most of these conditions those who had given attention to the subject would be agreed. He thought that others would agree with him that most of those conditions had already been fully recognised, and, for some considerable number of years past, acted upon in this country in the patient endeavours of those to whom had been entrusted the task of working out an efficient system of torpedo defence. At the very first time that attention was seriously directed to this subject—the time of the late American war—it was at once recognised that the application of electricity to the explosion of mines should form the foundation of any reliable system of defence, and upon that fundamental principle the systems which had been worked out in this country had been based. At the same time he thought, and he believed that others would think, from the study of the strong and weak points of electrical defence, that mechanical mines must not be lost sight of altogether, and that there might be circumstances and conditions under which it might be very advantageous to apply a reliable mechanical mine. There might, for example, be large tracts of water which it was almost impossible to command entirely by a system of electrical mines, and a portion of which might consist of shallow water to which vessels of light draught might have access, but which it would be possible to close entirely against friendly ships. In such localities, good reliable mechanical mines which might be laid down with safety, and which would be efficient for long periods, would be invaluable. He believed that such mines, if they did not exist, would be introduced in a short period, and would add importantly to the value of any general system of torpedo defence adopted in this or other countries. Mr. Holmes had not entered into details with regard to any particular system of defence or of electrical arrangements, and he (Professor Abel) could quite understand his hesitation in that respect; for the subject, though a new one, was a very vast one, and it would be difficult within the scope of a paper to give a satisfactory account of several systems which had already been very fairly tried. Mr. Holmes had, however, alluded to one portion of a particular system of electrical firing, and that was the employment of chemical fuses, as he called them, that is, fuses which were specially intended to be fired by currents of high tension. He had had very considerable experience in the application of these fuses to the explosion of both land and submerged mines, and there was no doubt a very great amount of truth and justice in what Mr. Holmes had said with regard to the liability to change of any mixture of chemical compounds, however permanent and stable these might be in their general characters. This liability to change arose not so much from a want of stability in the materials themselves as from the difficulty of excluding the access of moisture from a fuse, as constructed until very recently. Two essential components of a chemical fuse would be an oxidising agent and an oxidisable body; and the access of even a very small proportion of moisture to any mixture of such ingredients must, in time, establish action between these. He could well understand that fuses, or rather gun-tubes, such as Mr. Holmes had produced to the meeting, and which were originally designed simply for the purpose of firing the guns for proof at Woolwich and for experiments at Shoeburyness, would not withstand for any very great length of time exposure to a damp atmosphere. The liability to change which existed in fuses of this kind had been, if not entirely, at all events to a very great extent indeed, remedied, first of all by improvements in the construction of the fuse, whereby the access of moisture to the interior of the fuse was impeded, if not altogether prevented, and, secondly, by an improvement in the composition of the chemical preparation used. At the same time he ought to state his conviction that the system of igniting mines electrically, by means of fine wires, possessed many advantages; but it would be impossible for him then, and quite beside the question, to go into the comparative merits of the two systems of ignition. The means of ignition by wires was now being very greatly improved, and we should, before long, have abundant proof as to which was really the most permanently reliable system. As to the general question of this important system of defence, he was quite sure that its merits could not have been more ably put before the Society than they had been by Mr. Holmes that evening.

The Chairman stated that he should like to ask Professor Abel a question with regard to a system of torpedo which was both mechanical and electrical, and which had not been mentioned either in the paper or in his observations. He (the Chairman) thought that there was a system of combined mechanical and electrical torpedo used in the Adriatic during the Italian war, and he should like to hear some observations from Professor Abel on that combined system.

Professor Abel said that he believed that no system of defence by torpedoes in which electricity was applied would ever be allowed to depend entirely upon arrangements for exploding mines such as described by Mr. Holmes. Such arrangements were excellent, but they should only be adopted in conjunction with other systems. The system upon which, after all, very great, if not the greatest, reliance could be placed was such a system as that to which the chairman had referred, in which mechanical appliances are the means of completing an electric circuit, or of interrupting an electric circuit, in consequence of which operation the mine is exploded at the time a ship passes over it. The arrangement to which the chairman referred was that exhibited by Baron von Ebner, at the Exhibition of 1862. It was a very ingenious one for effecting this object. It was a mechanical arrangement so devised that the collision of a ship with the mine, or with the arrangement for firing the mine, determined its explosion.

The Chairman said that the battery had to be put to the circuit, and then the mechanical contact would fire the mine. Neither process alone would fire the mine,—neither the contact of the torpedo with the ship, nor the action of the battery, by itself.

Professor Abel assented. As far as he remembered Baron von Ebner's arrangement, one point that he desired to avoid was the possibility of fuses ever being in electric circuit with the cables until at the very moment the mine was to be exploded, and this was with special reference to the high tension fuses which he used. The object was to avoid what Baron von Ebner considered to be the risk of accidental explosions of mines by induced currents which might arise, especially in climates where there were great electrical disturbances, or be caused by the inductive charging of neighbouring cables. His mechanical arrangement was so devised that the ship completed the circuit at the moment of striking, and brought the fuse at the same moment into circuit, and then the torpedo exploded. But there were many other similar arrangements, and, as they might well conceive, since the subject had received very great attention of late years, arrangements of a comparatively very simple character had been devised for accomplishing the same ends, or at any rate similar ends. The contrivances known as circuit-closers and circuit-breakers were now indispensable adjuncts of an efficient system of submarine mines.

Mr. Holmes asked to be allowed to explain that, in speaking of mechanical means of firing as inadmissible, he had reference to cases in which the torpedo was submerged for a long time. The action of sea water or fresh water would cause incrustation or rust which would render any mechanical machine unreliable should it remain submerged for months. There was no doubt that, during warfare, when the submergence would be only for short periods, the introduction of mechanical mines would be advantageous. But for a permanent system of defence, his paper had reference simply to electrical mines, because if a mechanical mine was submerged for any length of time, incrustations must take place which would impair its efficiency.

Captain McEvoy (United States) said that he had listened with a great deal of pleasure and much interest to the paper of Mr. Holmes, and also to the remarks of Professor Abel. The subject, as had been justly remarked, was one of vast extent, and one which would not allow a speaker, on any short occasion, to go into details in reference to it. He had had some practical experience in torpedo warfare, but that had been in the past; but the improvements had been so rapid and so radical that he thought that a reference to that period would scarcely be of any interest to the audience. The improvements in electrical torpedoes were in the right direction. He partly agreed with Mr. Holmes that mechanical torpedoes should not be entirely relied upon; and he also agreed with Mr. Abel that they could not be entirely dispensed with. For instance, he thought that where a channel was defended by electric torpedoes, the flank should be protected by a mechanical torpedo of some sort. Again, for blockading an enemy in his port, when there was no chance of laying down a regular system of electric torpedoes, the use of mechanical torpedoes would be indispensable. Mr. Holmes had narrated a few instances with regard to the history of the operations about Richmond and Petersburg, in which operations he (Captain McEvoy) participated to some extent; but those would amount to very little. Mr. Holmes had paid a very just tribute to Captain Maury, who was one of the pioneers in devising and perfecting a system of electric torpedoes, and he had done him no more than justice. He believed that the torpedo which Mr. Holmes spoke of as having exploded in the James River was the only electric torpedo on record that ever destroyed a vessel in actual warfare. At Mobile there were no electric torpedoes. At Wilmington, a few were brought down, but never brought into actual operation. At Charlestown there was a very large one, over which one of the largest ironclads of the Federal Government lay many hours to bombard Fort Sumter. Many efforts were made to explode it, but without effect. There was some defect in the wires. He heard it stated at the Bureau, at Richmond, that the defect was caused by the wires under the sand having been cut by the wheels of an ammunition-wagon. That fact was unknown at the time, because the means of testing the electric torpedoes were then in a very defective condition. Had that feature of the system been as perfect as it was now, they would easily have ascertained the cause before the attack on Fort Sumter was begun. Had the torpedo been successful, three thousand pounds of gunpowder would have exploded under the largest ironclad then in the Federal fleet, with a result which we could only imagine. He saw the wreck of the *Commodore Jones* the day after it was exploded in the James River, and the demolition was perfect. The statement of Mr. Holmes was correct as to the effect on the vessel.

Mr. E. O. Brown said that Mr. Holmes's statements were certainly very satisfactory. The question of the different systems of the electrical firing of torpedoes was one about which they should hear a little more in the future. No doubt the crucial point upon which the practice of exploding torpedoes by electricity would depend was the question of which system was best adapted for the purpose.

The discussion was then adjourned.

A meeting of this Society took place on Wednesday evening last, the 25th ult. The chair was taken by Mr. Latimer Clark.

A further paper on "*Electric Torpedo Warfare*" was read by Mr. Nathaniel J. Holmes, the present contribution having especial reference to mining operations on land.

The discussion of the subject was continued by Major Malcolm, Professor Abel, Mr. Truenfeld, Lieutenant Scott, Lieutenant Watson, Mr. Arthur R. Granville, and the Chairman.

A vote of thanks was accorded to Mr. Holmes for his two papers.

An abstract of the proceedings will appear in our next issue.

The receipts on the Submarine Telegraph for the month of January, 1874, amounted to £8523, and for the corresponding month of last year to £8167, showing an increase of £356.

# Electrical Science in Foreign Journals.

## *Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences*, Vol. lxxviii., No. 5.

*Note on Magnetism.*—M. Jamin.—Reply to M. Gaugain. This note (referring to the theory of solenoids), can only be appreciated with its accompanying figure.

*On the Variable State of Voltaic Currents.*—M. Blaserna.—Reply to M. Cazin.

*On the Supposed Liberation of Ozone in Plants.*—M. Bellucci.

### No. 6.

*Safety Electric Cable Against Fires.*—MM. Joly and Barbier.—In this apparatus (of which a drawing is given) a bell is set ringing whenever fire breaks out in any part of the building through which the cable passes. The cable consists of two metallic wires insulated from each other by a layer of gutta-percha or like material, and strongly corded by a special process. Whenever any part of the cable gets heated through outbreak of fire, the insulating matter is fused, the two wires come into contact, and a circuit is thus completed, by which a current flows and affects the bell. For ascertaining that the cable keeps in good working order, the two other ends of the wires are connected with a peg commutator. On inserting the peg the bell ought to ring.

## *Il Nuovo Cimento*, Vol. x., Series 2.

*Rapidity of Depolarisation of Non-conductors.*—M. Felici.—In his experiments the author used an electrified inducing metallic ball (insulated), a cube shaped non-conductor, and a metallic disc connected with the earth. By a slight movement of one of two levers the ball could be connected with the earth; by movement of the other the disc could be disconnected; and they were so arranged that a descending weight moved them thus simultaneously (or with a very short interval). The non-conductor being placed between the inducing ball and induced disc, it could in this way be found how long the non-conductor retained polarisation after the inducing influence ceased. The good conduction of the pieces was first ascertained; the non-conductor being absent, the disc was proved to have no electricity when the ball had been connected to earth, and to be always electric when the connection of disc with earth was unmade before that between ball and earth was made. Then, on making the experiment with the non-conductor interposed, the effect was found exactly the same; however long the non-conductor was exposed to the inducing action of the ball, however great its polarisation, there remained *no trace* of this polarisation after the action ceased. A rough estimate showed the time to be $\frac{1}{1000}$ of a second, and M. Felici concludes that this is sufficient for non-conductors to be so depolarised that no action can be perceived in them, with the finest balance.

## *Poggendorff's Annalen der Physik und Chemie.* No. 11. 1873.

*On the Charge of Elasticity and Length in a Wire Traversed by a Galvanic Current.*—Dr. H. Streintz.—The results of this inquiry are thus summed up:—

(1). The galvanic current works a change in the elasticity of the conducting wire only through the heat produced.

(2). The current expands the wire more than a heating to the same temperature would; only in the case of hard steel there is no such difference.

(3). The galvanic expansion occurs, on closing of the current, not suddenly but gradually, like expansion by heat.

(4). It cannot be the result of an electro-dynamic repulsion, but probably consists in a polarisation of the heat-vibrations produced.

*On the Number of Ether Molecules Contained in Electric Conductors, and their Weight.*—M. Herwig.—In this preliminary notice the author comes to the conclusion that the number of molecules in a cubic millimetre of mercury must be less than $2 \cdot 10^{82}$; and dividing the number denoting the density of the free ether by this, we get the inferior limit of the weight (in milligrammes) of each ether molecule. It cannot be more than $\frac{1}{10^{100}}$.

*On Change in Pitch of Tones Through Movement of the Source of Sound, and Determination, by this Means, of the Velocity of Sound.*—Dr. Schüngel.—The author experimented with two tuning forks, No. 1 giving 512, and No. 2 508 vibrations in a second. Sounded together they gave four beats in a second. But suppose No. 2 moved towards the observer (situated beside No. 1), its quantity of vibrations will be increased and the number of beats diminished. Dr. Schüngel sought to measure —(1) the time in which a certain number of successive beats was audible; and (2) the velocity of the moved fork. His apparatus (which was electrical) may be briefly described:—A seconds pendulum at each swing closed a circuit, which, through a relay, caused a series of dots to be marked on a telegraph strip at intervals corresponding to seconds. By pressing a key another battery circuit could be closed, which had two effects: part of the current went to the relay, and produced a line in the telegraph paper so long as the key was held down; but the greater part went through an electro-magnet, which attracted an armature at one end of a lever, having at its other end a roller rotated by a cord from a fly wheel. The roller was thus pressed against the edge of a disc, which, thus set in motion, wound in, by a cord about its axis, a little wagon bearing the tuning fork (No. 2) with its case towards the observer. The method, with some suggested modifications, is commended to the attention of physicists for an accurate determination of the velocity of sound.

## *Monatsbericht der Konigl. Preuss. Akad. der Wissensch. zu Berlin.* Nov., 1873.

*Remarks on Aperiodic Motion of Deadened Magnets.*—Dr. Du Bois Reymond.—The author first describes an aperiodic magnet without astatic arrangement, the invention of Dr. Siemens. In a copper ball a cylindrical hollow is made, its axis coinciding with the vertical diameter of the ball. In it hangs a magnet, the shape of which may be understood by conceiving a steel bell (like a glove finger), from which two slices have been cut parallel to the axis and at equal distances from it. From the middle of the bend proceeds a rod in prolongation of the axis, by which the piece is suspended in the middle of the hollow, and to which the mirror is attached. This (sort of horse-shoe) magnet is called by its inventor a bell magnet. Its advantages are: high intensity of magnetisation; comparatively small moment of inertia; close proximity of the poles to the deadening metallic mass; and the deadening independent of deflection. In the remaining three sections of this paper, Dr. Du Bois Reymond discusses the different behaviour of aperiodic magnets with telescopic and macroscopic deflection; the best way of attaching Hauy's bar; and Sir W. Thomson's aperiodic magnets without deadening.

*On the Action of Electrophorus Machines and Double Induction.*—M. Riess.—Reserved for translation.

# City and Commercial Notes.

SUBSCRIPTIONS have been invited by the River Plate and Brazil Telegraph Company for £100,000 Seven per cent Debentures at 90, repayable in ten years at par, constituting a first charge upon the earnings of the Company.

The report of the Indo-European Telegraph Company (Limited), presented on the 27th ult., shows a balance of £1230, and states that:—"In the absence of any arrangement with the Post Office respecting the heavy deduction from receipts of £12.000 for wire rental, there is no sum available for dividend. The appeal of the Company against this excessive payment, supported by the recorded opinion of Mr. Scudamore that the Company is entitled to relief, is still before the Treasury, and the Directors have been, and still are, urging that the justice due to the Company shall not longer be delayed."

The ordinary general meeting of the Panama and South Pacific Telegraph Company was held on the 13th ult. at the Cannon Street Hotel, Mr. T. Hughes in the chair. The report was entirely occupied with the details of the Chancery suit going on between the Company and the contractors and Sir C. Bright, and the efforts of the directors to bring that suit to a termination. The chairman, in moving the adoption of the report, said that since it had been issued an order had been made by the Judges in Chambers setting down the cause for hearing in March.

The directors of the Telegraph Construction and Maintenance Company propose paying a dividend of 20 per cent (£2 8s. per share), in addition to the interim dividend of 5 per cent already paid, carrying forward about £19,359. At the corresponding period of last year the dividend was 24s. per share.

The Brazilian Submarine Telegraph Company (Limited) have notified that their cable between Madeira and St. Vincent is expected to be laid in March, and that on the announcement of its opening for traffic, pending the restoration of the Madeira-Lisbon section, messages for South America and the Cape of Good Hope will be received to be sent by wire to Lisbon, thence by post to Madeira, from there to St. Vincent by telegraph, and finally by post to their destination. The rate from Great Britain for messages of 20 words to St. Vincent will be £2 17s. 6d., including agency and postage. When the Lisbon-Madeira section is restored, the messages will be sent direct by wire from England to St. Vincent and thence by post at the same rates, with an additional charge for postage of 1s. 6d.

The annual meeting of Hooper's Telegraph Works Company (Limited) was held on the 16th ult. at the City Terminus Hotel, Mr. J. M. Dunlop in the chair. The report stated that there was a profit of £89,790, after deducting £15,000 for depreciation of plant and machinery, and a further sum of £17,852 for depreciation on the two cable ships *Hooper* and *Great Northern*. After payment of the sum due to Mr. Hooper according to the Company's contract with him, the amount available for distribution was £54,270. An interim dividend of 15s. per share, amounting to £18,750, was paid to the shareholders on the 19th of July last, leaving a balance of £35,520 for division among them now. The directors recommended a dividend of £1 per share, free of income-tax, which would absorb £25,000, leaving a balance of £10,520 to be added to the reserve fund, which would then amount to £26,241. Taking the dividend paid in July, together with that now recommended to be paid, the total amount distributed to the shareholders for the year would be at the rate of 17½ per cent, free of income-tax. The whole of the cables for the Western and Brazilian Telegraph Company had been most successfully completed and accepted by that company, and they were in full operation. The cables for the Central American Telegraph Company were in course of manufacture, and would be shipped on the return of the steamshid *Hooper*. The directors had obtained contracts, with concessions, subsidies, and guarantees from the Cape, Natal, and Mauritius Governments for submarine cables from the Cape, *via* Natal and the Mauritius, to Aden. The capital account showed that £250,000 had been expended. The Chairman, in moving the adoption of the report, congratulated the proprietors on the making and laying of the cables. The perfect success with which the Western Brazilian telegraph was laid from Bahia to Rio Janeiro, 2500 miles in length, was gratifying. It had been tested on the 27th of January, and was in good order. The ships *Hooper* and *Great Northern* were fitted up with machinery for laying and picking up cables. The sum of £32,851 was a large amount to set aside for depreciation, and they had £229,000 in securities of other companies which the Company had taken over, and they had since increased in value. A dividend of 20s. per share was declared, free of income-tax. Mr. J. M. Dunlop, the retiring director, was re-elected; and Mr. J. O. Chadwick and J. Pegler, the retiring auditors, were also re-elected. A vote of thanks to Mr. Hooper, the managing director, and also to the directors for their attention to the interests of the Company concluded the proceedings.

The annual general meeting of the Anglo-American Telegraph Company (Limited) was held on the 13th ult. at the London Tavern, Viscount Monck in the chair. The report stated that the directors of the French Atlantic, New York, Newfoundland, and London Telegraph Companies had joined the Board of this Company. The total earnings previous to the amalgamation for the four months ending April 30, 1873, including a balance of £16,000 brought over, amounted to £132,784. The ordinary expenses, including income-tax, amounted to £11,517, leaving a balance of £121,267. Out of this sum dividends amounting to £67,000 were paid, leaving a balance of £54,267, which was carried to the renewal fund of the amalgamated company, in accordance with the terms of the agreement, dated the 25th of June, 1873. The total receipts for the eight months from the 1st of May to the 31st of December last amounted to £547,906. The working and other expenses, including income-tax, amounted to £218,817, leaving a balance of £329,089. Out of this an interim dividend of 2 per cent had been paid, absorbing £140,000. The directors had set apart £40,000 for the new works and renewal fund, thereby increasing that fund to £254,947, leaving a balance of £149,089. The directors recommended that £140,000 of this amount be appropriated to the payment of a further dividend of 2 per cent, free of income-tax, which, with the interim dividend already paid, would make up a total payment on the capital of the Company at the rate of 6 per cent per annum for the eight months ending December last, carrying forward a balance of £9089. The expenditure on capital account amounted to £7,000,000. The chairman, in moving the adoption of the report and declaration of the dividend, said that it amounted with the interim dividend to 6 per cent for the eight months, which was about equal to 14 per cent on the Anglo-American Company's capital. The amalgamation took effect on the 1st of May last year, but the accounts hardly did justice to the strength of their position; they had a reserve-fund of £254,947, which, with 900 miles of deep sea cable, was worth £300,000, giving them a reserve of £500,000. They had added £40,000 to the reserve fund on the supposition that the shareholders would adopt the course suggested by the Board. By the change of route of the 1873 cable the Company became possessed of 900 miles of deep sea cable saved out of the length provided for the Porthcurno and Halifax line. The Company had also about 126 miles of core in stock capable of being made up into cable. The directors had determined to utilise this cable by laying a fifth line from Ireland to Newfoundland in the coming summer, with a view to provide for the further development of the constantly increasing traffic. A contract had been entered into with the Telegraph Construction Company by which, for the sum of £475,000, they had undertaken to manufacture 1100 miles of new cable and lay it, together with the cable already possessed by the Company, between Valentia and Newfoundland. The greater portion of that sum would be furnished from the existing renewal fund and the surplus profits of the present year. With three of the cables in operation they could work their business well. The average time of sending a message between London and New York was 12 minutes 35 seconds, and, as messages came generally in a lump together, the proposed cable would give them still greater facilities for working at particular hours of the day. It was unanimously agreed, on the suggestion of Mr. Ford, to hold half-yearly meetings; but the directors could not undertake to pay quarterly dividends.

The half-yearly meeting of the Submarine Telegraph Company was held on the 24th ult. The report stated that, in comparing the half-yearly accounts with those of the corresponding period of 1872, there was a reduction of £341 in the receipts. The net profits for the six months ending the 31st of December, 1873, enabled the directors to add 5 per cent of the gross receipts to the reserve fund, and to recommend a dividend at the rate of 16½ per cent per annum. The Chairman, in moving the adoption of the report, said the decrease arose from the fact that certain gross profits which the directors had formerly appropriated to the Company were now divided with the Post Office. The directors considered this profit belonged to the Company, and on the Postmaster-General claiming them the question was referred to counsel, and counsel decided against the Company; but the steady progress of the Company's receipts, he anticipated, would soon more than cover this slight drawback. Mr. T. Nelson seconded the adoption of the report, but remarked on the cost of repairs to the steamer amounting to more than £400. The Chairman said the repairs to the steamer were calculated at £300 a year, and this was the first amount for repairs. A long discussion ensued with regard to the action of some of the directors with regard to the Light Cable Company between England and America, in the course of which Mr. Otway assured the proprietors that no arrangements of an exclusive nature had been made by this Company, or would be made, for this Company would hold itself the carrier for the Continent. He considered, however, that it would not be possible to limit the cables across the Atlantic, and time would show that still more were necessary. The report was ultimately adopted, the dividend agreed to, and a vote of thanks to the directors carried. In reply to the vote of thanks, the Chairman said the more agreements the Company made without binding them to payments the better it would be for the proprietors.

The report of the India-Rubber, Gutta-Percha, and Telegraph Works Company, Limited, for the year ending 31st December, 1873, to be presented at the meeting of shareholders, at the City Terminus Hotel, Cannon Street, on Tuesday, the 3rd inst., states that the net result of the year's trading shows a credit balance of only £9089 14s. 6d. to be transferred to profit and loss account, which, with the amount £32,500 2s. 1d. brought forward from the year 1872, makes a total of £41,589 16s. 7d. The general business of the Company has been fairly remunerative, but the expenses incurred in the, at length successful, efforts to pick up and repair the Colon and Jamaica Cable have absorbed a very large proportion of the profits. Under existing circumstances the directors do not recommend the declaration of a dividend, and they on their part have agreed to renounce their personal remuneration for the year 1873. A special agent has been despatched to South America in order to obtain concessions for cables along the Pacific coast from Peru to Chili. He has arranged matters satisfactorily with the Peruvian Government, and has now gone to Valparaiso. The steamship *Dacia* now proceeds to lay a short cable between Marseilles and Barcelona, and the *International* is on her homeward passage from New York, having finished, to the entire satisfaction of the United States Government, the Torpedo Cable contract.

## *TELEGRAPH SHARE LIST.*

| Amount per Share. | Name of Company. | Amount paid up. | Closing Quotations. |
|---|---|---|---|
| £ | | £ | Feb. 27. |
| Stock | Anglo-American (Limited) .. .. | 100 | 80½—81½ |
| 10 | Brazilian Submarine.. .. .. .. | 9 | 3½—2⅞ dis. |
| 10 | Cuba .. .. .. .. .. .. .. .. | All | 7¼—7¾ |
| 10 | Direct Spanish .. .. .. .. .. | 9 | 1 dis.—par |
| 20 | Direct United States Cable .. .. | 17 | 6—5 dis. |
| 10 | Eastern (Limited) .. .. .. .. | All | 7¾—7⅞ |
| .. | Do., New .. .. .. .. .. .. | .. | ..—.. |
| 10 | Eastern Extn. Australia and China | All | 8—8¼ |
| 10 | Globe Telegraph and Trust .. .. | All | 7⅛—7⅜ |
| 10 | Do., 6 per cent Pref... .. .. .. | All | 9⅛—9⅜ |
| 10 | Great Northern .. .. .. .. .. | All | 9¾—10¼ |
| 25 | Indo-European .. .. .. .. .. | All | 15½—16½ |
| 10 | Mediterranean Extension (Limited) | All | 4—4½ |
| 10 | Do., 8 per cent Pref... .. .. .. | All | ..—.. |
| 10 | Panama and South Pacific .. .. | 2½ | ..—.. dis. |
| 8 | Reuter's.. .. .. .. .. .. .. | All | 11¼—11¾ |
| Stock | Submarine .. .. .. .. .. .. | 100 | 235—245 |
| 1 | Do., Scrip .. .. .. .. .. .. | All | ..—.. |
| 10 | West India and Panama .. .. .. | All | 5—5¼ |
| 10 | Do., 10 per cent Pref. .. .. .. | All | 9⅝—9⅞ |
| 20 | Western and Brazilian (Limited) .. | All | ..—.. |
| 1000 dls. | West Un. U.S. 7 per cent 1st M.B. | All | 104—106 |
| 10 | Hooper's Telegraph Works .. .. | All | 13—13½ |
| 50 | India-Rubber and Gutta Percha .. | All | 23—25 |
| Cert. | Submarine Cables Trust .. .. .. | 100 | 108—110 |
| 12 | Telegraph Construction .. .. .. | All | 33—33½ |
| 100 | Ditto Ditto 7 per cent Bonds | All | 101—103 |

## Patents.

1641. G. Haseltine, of London, Doctor of Laws. *An Improved Process and Apparatus for Effecting and Maintaining a Separation between two Dissimilar Liquids or between a Liquid and any Substance held in Solution or Suspension therein; parts of which Invention are Applicable to the Construction of Galvanic Batteries, and to the Refining of Spirituous and Vinous Liquors.* (A communication from F. L. Pope, of Elizabeth, New Jersey, and W. H. Sawyer, of New York, telegrapher, both in the United States of America.) Dated May 7, 1873.—This invention consists, first, in a process for separating two liquids or freeing a liquid from any substance held in solution or suspension therein. Second; in the combination of a galvanic battery, or other suitable generator of electricity, a vessel for containing liquid, and a continuous conductor capable of being traversed throughout by a current of electricity. Third; in a galvanic battery having its negative element formed of a circuitous conductor. Fourth; in the combination of a feeding tube or reservoir with a battery, whereby the negative salt may be supplied without interrupting the action of the battery.

3290. G. Haseltine, of London. *Improvements in Electro-Magnetic Railway Signal Apparatus.* (A communication from T. S. Hall, of Connecticut, and A. L. Van Blarcom, of New Jersey, both of the United States of America). Dated October 10, 1873.—This invention consists in a series of signal-houses arranged in combination with line wires which connect with electro-magnets in the signal-houses and with track instruments; one battery serves to vitalise the electro-magnets whenever the wheels of a passing train act on the corresponding track instruments; also in the combination of signals of safety with signals of danger arranged on the line of a railway in pairs, said signals being operated alternately by electro-magnetism and by gravitation; further, in the arrangement of a locking lever in combination with each signal; also in the combination of a piston with the key lever of a circuit closing instrument and with a track lever in such a manner that when the piston is forced upwards to operate the key lever an air cushion is formed on the cylinder which prevents the piston from being slammed against the cylinder head.

### UNITED STATES.

143,298. D. L. Parkhurst, San Francisco, Cal. *Mechanical Key and Sounder for Telegraphs.*—Dated August 1, 1873.—Underneath lever a thin strip of metal is attached, which gives the sound by being bent or crinkled by the lever.

143,340. M. Gally, Rochester, N. Y. *Circuit Closer and Circuit for Multiplex or Interval Telegraphs.* Dated September 22, 1873.—Metal strips of rotating circuit closer, let in diagonally. System of circuits and switches so that any transmitter or receiver may be thrown into circuit for use at any unemployed interval.

143,344. J. H. Guest, Brooklyn, N. Y. *District and Fire Alarm Telegraph.* Dated September 22, 1873.—Combining a series of thermostatic alarms with the normally closed circuit of a district alarm telegraph, in such a manner as not to interfere with the closed circuit unless acted on by heat, when an alarm is given. The combination, with a district alarm signal-box or series thereof, of one or more alarm mechanisms, operated directly through changes of temperature, and arranged in the normally closed circuit of such alarm signal boxes.

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Electricity and the Electric Telegraph.—Mr. John Faulkner, of Manchester, recently delivered a lecture on this subject at the Winter Evening Lectures of the Poulton Le Fylde Church School. The Rev. W. Richardson, M.A., vicar, occupied the chair. The lecturer briefly alluded to the various sources of electricity; to the different kinds of telegraphic batteries; and to the condition and effects of electric currents; The illustrations were intended to show that, what is understood as magnetism, is only an effect of electricity in motion. Without iron or steel attractions and repulsions were exhibited. Powerful electro-magnets showed the great strength such apparatus are capable of developing, and the readiness with which they receive and give their power. As to this force being ever utilised as a motive power, the lecturer intimated that all experiments went to show that the wrong track had been pursued, and ventured to suggest, that were the pulsations of controllable electro-magnetism resorted to, better results might accrue; but so long as the long stroke or crank motion of the steam engine was aimed at, failure might be considered inevitable, as intense magnetism only operated through very short distances. The action of the single needle, printing, bell, duplex, and alphabet instruments, was clearly illustrated. Several telegraph clerks from Preston and neighbourhood were present, and had four instruments in operation; a number of messages were written by various persons present, and sent to others in the room; some of them causing much amusement. The lecturer suggested the introduction of schools of telegraphy into our workhouses and hospitals.

Iron Electrotypes.—M. Klein, a Russian chemist, describes the following process for obtaining iron electrotypes:—The bath employed consists of a concentrated solution of sulphate of iron and ammonia; and the battery of Meidinger cells. For an anode an iron plate is used, with a surface about eight times that of the cathode, and connecting this with a copper plate, a perfect coating of iron is obtained. On leaving the bath the iron, it is said, is as hard as tempered steel, and very brittle. When heated, however, to a cherry red, it is said to become malleable, and may then be engraved as easily as soft steel.

Pneumatic Tubes.—An important extension of the system of pneumatic tubes being rendered necessary by the removal of the Telegraph Department of the General Post Office, the subject was referred to Mr. Robert Sabine, so as to insure economy and efficiency. A recent number of *Engineering* contains a full account of these investigations, from the results of which Mr. Sabine draws the general conclusions that, in regard to the proposed extension of the pneumatic tube system in connection with the Postal Telegraph Department:—1. The most economical results will be found from the employment of an entire 2¼ in. lead tube system; 2. The pressures best suited for working are 10 lbs. pressure, 6½ lbs. vacuum for all lengths; 3. The engine power necessary to be provided will be 150 horse power, of which not more than 30 per cent may be used in internal friction, &c., and the remainder in providing about 1000 cubic feet of compressed air and 2000 cubic feet of rarefied air per minute.

Fein's Galvanic Battery.—In an Austrian journal we find a description of a battery made by Fein, in Stuttgart, which is said to combine great electromotive force with great constancy. It consists, in the first place, of a three-necked bottle, like a Woulf's bottle. In one of the side necks is a carbon rod, and in the other is an amalgamated zinc rod, provided with a cotton cover as substitute for a porous cell. The bottle is filled through the middle neck to two-thirds its capacity with a mixture of black oxide of manganese and pieces of gas carbon; the remaining third is filled with a concentrated solution of sal-ammoniac. This neck is then closed by means of an inverted glass flask filled with a concentrated solution of sal-ammoniac, and so placed that the mouth of the flask dips beneath the surface of the solution in the bottle. If water enough evaporates to bring the surface of the solution below the mouth of the flask, some air will enter the flask, and enough solution flow out to preserve a constant level. The copper conductor is attached to the carbon rod by first covering it with platinum foil, then making a slit in the carbon and depositing a film of copper by electrolysis, and finally pressing the platinum strip into this slit and soldering it with tin. This battery is said to require cleaning about once a year, when the zinc rods must be amalgamated anew.—*Journal of the Telegraph.*

A New Submarine Atlantic Cable Scheme.—A bill has been introduced in the House of Representatives to incorporate the Submarine Cable Printing Telegraph Company of Boston and New York capitalists, to lay and operate one or more lines of Atlantic cable, section 4 of which is as follows:—"That the tolls for governmental, commercial and private messages over the line or lines of said company shall not exceed 50 cents per word, and for press dispatches shall not exceed 25 cents per word." The enterprise is founded upon two new methods for ocean telegraphing, invented by W. E. Sawyer, a Washington journalist.—*Journal of the Telegraph.*

## To Correspondents.

⁂ Duly authenticated contributions, theoretical and practical, on every subject identified with the interests of which "The Telegraphic Journal" is the organ, will always command attention. Anonymous correspondence will be wholly disregarded. Literary communications and books for review should be addressed to the Editor; business communications to the Publisher.